

task_p8yrdjr60k6bvc4n_with_calculation

Student Group

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charging, capacities, exam ee1 SS2023

**Exercise E4 (Dis)Charging Capacities
(written test, approx. 14 % of a 60-minute written test, SS2023)**

The circuit below is initially closed with all switches (\$S_1\$ and \$S_2\$) in the drawing. What will be the results on a page of \$t_0\$ that \$S_1\$ switches to the situation shown in the drawing. What is the time constant?

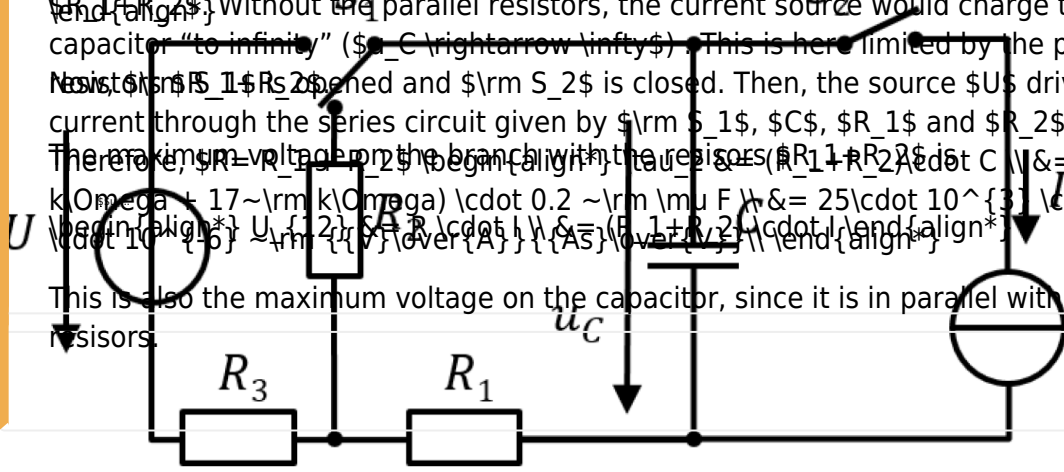
- \$C_1 = 200 \text{ nF}\$

Solution: $R_1 = 8.0 \text{ k}\Omega$
 Solution: $\tau = (R_1 + R_3) \cdot C_1 = (8.0 \text{ k}\Omega + 7.0 \text{ k}\Omega) \cdot 200 \text{ nF} = 3.0 \text{ ms}$
 Solution: $U_C = U \cdot \frac{R_2}{R_1 + R_2} = 10 \text{ V} \cdot \frac{17 \text{ k}\Omega}{8 \text{ k}\Omega + 17 \text{ k}\Omega} = 5.6 \text{ V}$
 Solution: $I = \frac{U}{R_1 + R_2} = \frac{10 \text{ V}}{25 \text{ k}\Omega} = 0.4 \text{ mA}$

The current of the source flows through the circuit consisting of \$C_1\$ in parallel with (\$R_1 + R_2\$). Without the parallel resistors, the current source would charge the capacitor "to infinity" (\$C_1 \rightarrow \infty\$). This is here limited by the parallel resistors. \$S_1\$ is opened and \$S_2\$ is closed. Then, the source \$U\$ drives the current through the series circuit given by \$S_1\$, \$C_1\$, \$R_1\$ and \$R_2\$.

Therefore, the voltage on the branch with the resistors (\$R_1 + R_2\$) is $U_C = (8 \text{ k}\Omega + 17 \text{ k}\Omega) \cdot 0.2 \text{ mA} = 25 \cdot 10^3 \cdot 0.2 \cdot 10^{-3} \text{ V} = 5 \text{ V}$.
 The voltage on the capacitor is $U_C = (R_1 + R_2) \cdot I = 25 \text{ k}\Omega \cdot 0.4 \text{ mA} = 10 \text{ V}$.

This is also the maximum voltage on the capacitor, since it is in parallel with the resistors.



Before \$t_0\$ all switches are switched as shown and the capacitor is fully discharged. At \$t_0 = 0 \text{ s}\$ the switch \$S_1\$ shall switch to the voltage source.

1. Calculate the time constant for charging the capacitor.

Solution

The time constant is generally given as: $\tau = R \cdot C$

Once \$S_1\$ is closed and \$S_2\$ is open at \$t_0\$, the source \$U\$ drives the current through the series circuit given by \$S_1\$, \$C_1\$, \$R_1\$ and \$R_3\$.

Therefore, $R = R_1 + R_3$
 $\tau_1 = (R_1 + R_3) \cdot C_1 = (8 \text{ k}\Omega + 7 \text{ k}\Omega) \cdot 0.2 \text{ }\mu\text{F} = 15 \cdot 10^3 \cdot 0.2 \cdot 10^{-6} \text{ s} = 3.0 \text{ ms}$

Solution

Both courses of the voltage for charging and discharging are described with an exponential function. However, the curve for charging increases first steep and flattens out for longer time scales ($\propto (1 - e^{-x})$).

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